Heavy-Duty Vehicles

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What alternative fuels available are used in medium/heavy duty?

- Alcohol Fuels
  - methanol
  - ethanol
- BioDiesel
- Gaseous Fuels
  - propane (LPG)
  - natural gas (CNG & LNG)

Example Medium/Heavy Duty Vehicles

- School Bus
- Transit Bus
- Shuttle Bus
- Refuse Hauler
- Vocational Truck (classes 6,7 & 8)

School Bus


SCHOOL BUS
STOP
WHEN
RED LIGHTS FLASH
56
CLOVIS
UNIFIED
SCHOOL
DISTRICT
FleetStar

Transit Bus

Refuse Hauler

Propane Bobtail Truck

Alcohol Fuels

- Ethanol
- Methanol
- Renewable or Fossil Fuel Feedstock
  - Ethanol from fermentation of agricultural products
  - Methanol from wood
  - Either alcohol fuel can be made from crude oil or natural gas

Methanol

- Derived from wood or fossil fuels
- MTBA (methyl tertiary butyl ether)
- Gasoline additive

Ethanol

- Derived from bio-mass or fossil fuels
- ETBA (ethyl tertiary butyl ether)
- Gasoline additive

Benefits and Limitations of Alcohol Fuels

- Renewable from wood and bio-mass
- Lower CO and NO_x possible
- High efficiency and power
- Both Methanol and Ethanol failed in transit bus service, Los Angeles MTA 1989
- Corrosive and toxic (methanol especially)
- Highly subsidized by government

BioDiesel

- Considered an alternative fuel
- Portion of gallon derived from bio-mass
  - soybean oil
  - rapeseed oil
  - other vegetable and animal fats
- Typical blend-20% soy ester, 80% diesel

BioDiesel

Benefits and Limitations of BioDiesel

- Renewable portion reduces diesel consumption
- Retains thermal efficiency of diesel
- Fits infrastructure and vehicle technology
- Cost
  - 50 plus % more than diesel
- Minimal emissions reduction compared to diesel

Gaseous Fuels

- Propane/LPG
- Natural Gas
  - CNG (Compressed Natural Gas)
  - LNG (Liquefied Natural Gas)
- Hydrogen

Propane

- Used in lighter load, medium duty service
- LPG is popular in many airport shuttle and airport support services
- LPG is widely used for delivery service and light and medium duty transit
- Propane engines not used for very heavy load applications- transit, trash or over the road truck

Propane Bobtail Vehicle

Benefits and Drawbacks of Propane

- Excellent engine performance with current engine technologies
- CNG & LNG engines identical
- Reliable domestic fuel supply
- Fueling infrastructure best of all alternative fuels
- Characteristics of LPG make it “misbehave” in the heavily loaded engine

Natural Gas

- CNG and LNG Applications
  - transit buses
  - refuse haulers
  - vocational trucks (classes 6, 7 & 8)
    - short haul freight-CNG
    - short haul delivery-CNG
    - long haul (over-the-road)-LNG

Transit Buses

Refuse Hauler

Shuttle Bus

CNG

- Transit buses and refuse haulers are good candidates
  - centrally fueled
  - fixed route
  - capable of heavy, large storing fuel cylinders
- Vehicle range can equal diesel
  - 5 to 6 times the weight and volume in fuel storage compared to diesel

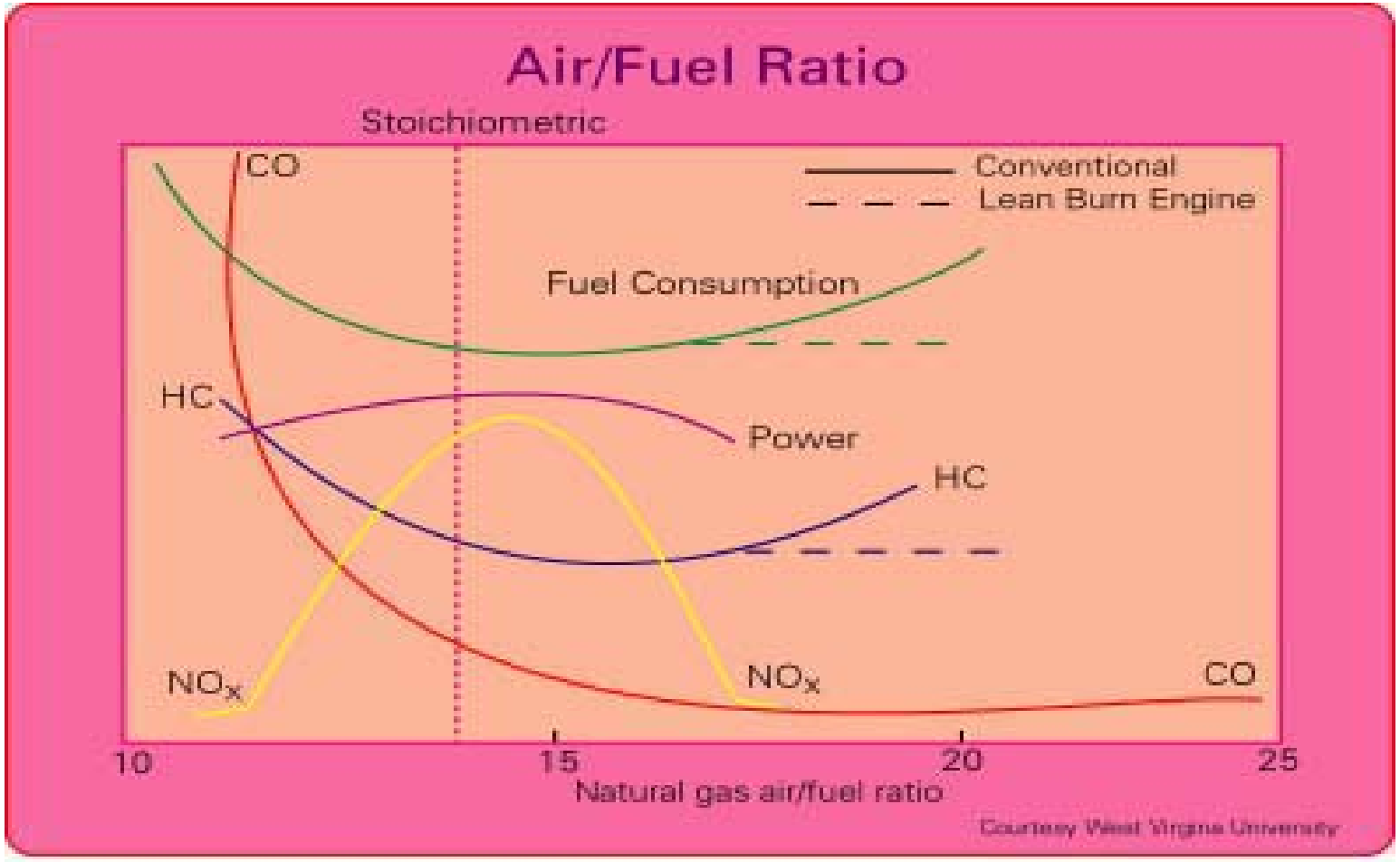
CNG continued

- Natural gas and diesel engine performance are equal
  - Torque and Horsepower
- Fuel consumption can meet diesel efficiency
- Operating costs may be lower than diesel
  - Maintenance/Repair
  - Fuel Costs

CNG continued

- Natural gas engines are quieter than diesels
- CNG powered buses replace dirtier, older diesel technology
- Current CNG engine technology is very robust
- Cleaner burning than diesel in:
  - CO
  - NOx
  - PM

CNG – Air/Fuel Ratio



Typical fuel consumption, power and emissions curves.

LNG

- All the same vehicle applications as CNG with much greater range
- Better fuel energy storage and vehicle range than CNG
  - over-the -road class 7 & 8 trucks
  - over-the-road transit coaches

LNG Storage

LNG (continued)

- LNG is >98% **methane**, the principle hydrocarbon component of natural gas
- Natural gas (CNG) is between 80% and 97% methane content
- Excellent engine performance can be achieved with pure methane

Benefits and Limitations of CNG & LNG

- Excellent engine performance with current engine technologies
- CNG & LNG engines identical
- Reliable domestic fuel supply
- Vehicle range limited
- CNG more prevalent than LNG
- CNG & LNG quieter than diesel

Benefits and Limitations CNG & LNG (continued)

- High pressure fuel storage (CNG)
- Cryogenic fuel storage (LNG)
- Fueling infrastructure spotty and expensive to build
- Fuel Price fluctuations
- Efficiency of engines lower than diesel, depending on duty (operating) cycle

CNG Tanks

Transit Bus – CNG Tanks Stored Top of Bus

Benefits and Limitations of CNG & LNG

- Range limited to fuel supply and storage
  - fuel station location
  - fuel storage capacity on-board vehicle
- CNG more prevalent than LNG
  - regional applications
  - gas production
  - infrastructure

Benefits and Limitations of CNG & LNG

- High pressure fuel storage (CNG)
  - Gaseous state stored
  - 3000psig
  - 3600psig

CNG Refueling - Dispenser

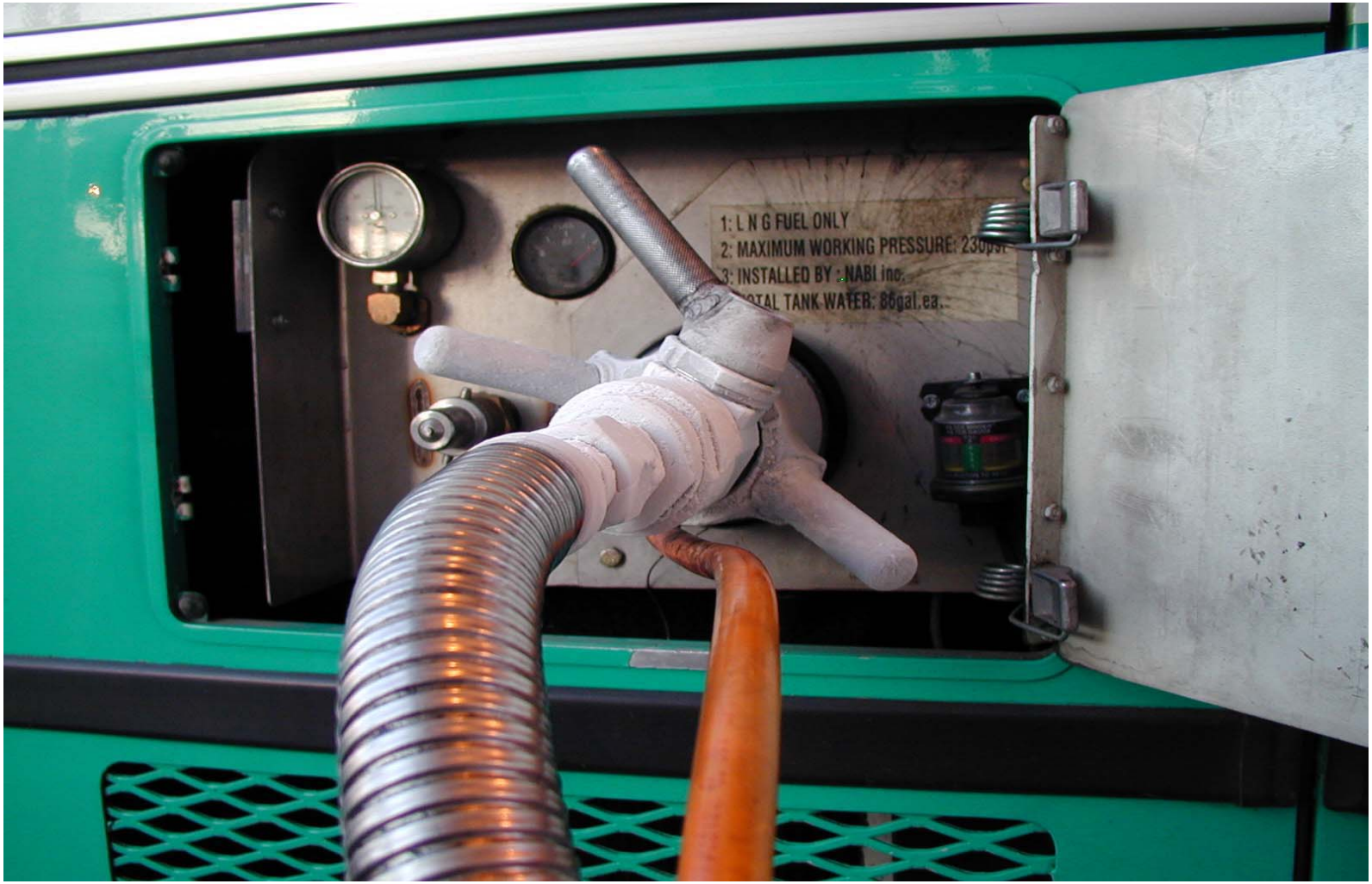
CNG Refueling – Transit Bus

Benefits and Limitations of CNG & LNG

- Cryogenic fuel storage (LNG)
  - Liquid state stored
  - -230ºC (-259ºF)

LNG Refueling

LNG Refueling



LNG Refueling

CNG Fueling Stations

- Time (slow) fill
  - common in fleet vehicles that fuel once daily, over night
  - less expensive to build amply sized compressor station for large fleet needs

CNG Slow-Fill Application

CNG Slow-Fill Application

CNG Slow-Fill Application

CNG Fueling Stations

- Quick (fast) fill
  - common for fleet and non-fleet vehicles
  - fill time similar to diesel and gasoline
  - private and public access stations
  - more expensive to build fueling station

CNG Fast-Fill Application

CNG Fast-Fill Application

CNG Fast-Fill Application

Hydrogen

- The Fuel of the Future

Operator and Technician Training

- Alternative fuels require specialized training for vehicle operators
- Fuelers, maintenance and repair personnel require unique knowledge and certification
- Nationally uniform training in is available throughout the US
- Well-trained and skilled technicians are and essential component to successful implementation

Operator Training

Technician Training

Operator and Technician Training

- Well-trained and skilled technicians are and essential component to successful implementation
- Training is an ongoing necessity
- Technicians who are knowledgeable in many fuels make better all round technicians

Conclusion

- Alternatively fueled vehicles are no longer alternative
- Greater implementation of alternative fuels and power-trains is inevitable

Conclusion

Conclusion

- Gaseous Fuels (LPG, CNG & LNG) are “bridge fuels” to the hydrogen age
- LPG, CNG & LNG are excellent IC engine fuels
  - stoichiometric
  - lean-burn
  - dual-fuel

Conclusion

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Conclusion

- Hybrid vehicles implement highly efficient and clean gaseous fuels technologies
- Fuel cell vehicles are on the way
- Training and general information from experienced (seasoned) professionals are available

THANK YOU!

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